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WORK SHOPS.

THEIR DESIGN AND CONSTRUCTION.

(To be read in October or November.)

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The author wishes to record a few notes on the design and construction of railway shops, not only of the peculiarities that mark those of North America, but also at some points to contrast them with European practice, and if possible to indicate what is and what may be the modern development and progress in this art.

THEIR LOCATION.

A natural starting point is the location of the shops with reference to the terminal stations of the railway, and to some large town; also the choice of land and its amount. A statement of the best American practice in this matter is given by Mr. C. Paine in the chapter on "Shops and Engine Houses" in his "Elements of Railroad Engineering." A point he strongly emphasizes, that more than enough land should at first be purchased (even if afterwards it is sold as building lots), will receive your endorsement.

FOUNDATIONS.

It would for our present purpose, be a waste of time to enumerate those matters common to all dry, solid and effective foundations, but it may be remarked that in Northern climates, it is better that the sides of foundation walls and piers be sloped rather than stepped, so as to prevent as much as possible the earth gripping the wall, as it expands under the action of frost.

When the main supports of the overhead weights—such as roof-principals, crane-tracks, shafting, etc., are iron pillars; and "made ground" covers to any depth the natural foundation bed, the comparatively low price of iron has proved it to be economical to build short foundation piers, and to allow the iron pillars to run down below floor level, to the piers, instead of carrying up the piers to floor level, the pillars being socketed into broad cast-iron bases, bedded in cement.

Pillar footings and column bases when above floor level are usually bedded on rolled sheet or melted piglead. The author is of the opinion that the running in between base and cope stone, of a fine cement grout would be quite as neat and effective, and certainly cheaper. Less concentrated weights, such as stationary engine and pump beds, and the footings of heavy machine tools, are satisfactorily bedded into their foundations with melted stick-sulphur.

Another instance of iron being used, to reduce the first cost of foundation, may be seen in the new erecting shop designed for the G. T. Ry. at Stratford, by Mr. H. Wallis (member), where, instead of making continuous walls to carry the rails supporting the traverser table, it was found less costly and quite as efficient, to build disconnected piers, and span them with wrought ironbeams of — section, which carry the rails laid upon them longitudinally, and support the flooring laid transversely.

WALLS.

It is advisable to emphasize the apparent wall construction; a good shop looks substantial. This is best accomplished by using bold pilasters or large piers to receive all roof and floor beams, setting them so that they stand out prominently, and spanning the panel between them with comparatively thin bonded walls, and if of brick, free from bats.

This method of straight lines and prominent offsets not only satisfies the eye, but is of pronounced value in localizing and absorbing the vibrations received from the roof or machinery, and closer attention to these matters would result in our shops having a less tame—a less ugly—appearance, and a longer safe life. The permitted outlay on such new works rarely admits of the wall surface being broken into ornamental lines, or varied in colour; but it is always possible to make a strong bony skeleton, whose very angularity shall instinctively satisfy, by appearing to be quite equal to special duty.

ENGINE HOUSES OR LOCOMOTIVE SHEDS.

Intended for little else than the temporary storage of locomotives engine houses in America vary more in first cost and permanence of material used than in type of design. The ordinary arrangements in plan is an annulus or segment of an annulus—whose centre is that of the unroofed turntable giving administration to the radial tracks, each leading into a single locomotive stall. The economies in the construction of the annulus are, either a narrow span of trussed ridge roof; or a so called flat roof (angle 5°), offering little obstruction to wind, and permitting the use of an inexpensive roof covering: Low walls—the roof timbers are sometimes lower than the top of the engine chimney; and short length of wall, as it is limited to the ends and outer ring, the inner ring being formed by the wooden door and door posts. A flat roof sup

ported by pillars gives a very stiff building for the limited amount of material used, and if sloped inwards, the roof drainage is a simple matter.

The chimney of the locomotive naturally going to the higher part of the building brings its front end close to the outer wall containing the windows, so that the most light is received where it is needed—on the moving parts of the machine.

Extending back into sparsely settled districts, as do many of the new railways on this continent, the primary consideration, in the erection of their buildings, is low first cost, trusting to a future development of traffic to provide the revenue for erecting permanent structures. Hence, segmental engine houses of wood, with flat gravel covered roofs are common, and if the materials for the asphalt—and its drainage—do not prove unusually expensive, they can be built for \$850 per stall, the foundation being cedar posts, 6 or 8 feet apart, carrying a mud sill, on which rests a pine frame of scantling from 6 to 8 inches square, the roof single sheeted with 1 or 1½ in. tongued boards, and coated with paper felt, tar and gravel; asphalt of brick or stone 25 ft. long, and one iron smoke jack. A similarly roofed building with brick walls costs about \$1600 per stall.

It was common some years back in northern climates to sheet with inch boards on both sides of the scantling, and to fill in between with sawdust. This hastened decay by holding water and vermin, and the better practice now prevails of putting both sheetings outside, with tarred felt or thick paper between them. The use of clapboards or shingles for outside sheeting, much improves the otherwise primitive appearance of such an engine house.

The more permanent structures of this class are of brick, and those of modern date have roof principals, rafters and deck ridge beams of wrought iron throughout; the covering being of slate, preferably of small size, 8 by 16 or 9 by 18, with a quick angle or slope at least equal to ½ of span, which is never less than 66 ft.

In Canada slate is rarely used for shop roof-coverings. Mr. J. W. Harkom (Member) informs the Author, that he has used New-Rockland slate on an engine-house in Maine for five winters without repairs being needed, and he is familiar with roofs that have been covered with it for ten years, that show no injury from frost. Our native slates are very compact,—a point greatly in their favour. A report of the State Geologist for Vermont shows that the slate in this neighborhood has a water absorption (under vacuum test) of but ⅓ of its weight. Mr. Harkom also mentions a successful experiment he carried out at Arthabaska, with the object of getting rid of the icicles that form at eaves, due to melting from heat communicated through the roof slating. He double-boarded or sheeted on the purlins, and then laid wood strips 1½ by 1 inch thick on top, at proper distance apart, to which strips the slates were nailed. The air space below secures fairly equal temperature on both sides of the slate, thus preventing the excessive eave icicles common to slate covered engine-houses.

The fire risk from a roof covering of shingles—set in cement and occasionally lime-washed,—is very slight; in fact in high winds, with many live sparks flying about, it is probable that shingles so treated are safer than slate.

A liberal surface of glass is provided in the outer ring wall. Skylights flush with roof, being difficult to keep clean both inside and out, are of little use; and the small portion of each large door (forming the inner ring) that can be fitted with windows, makes it necessary to depend largely on the outer ring wall for natural light.

As to the number of engine stalls required, any railway in a moderate climate, having an engine house capacity equal to 60 per cent. of its locomotive stock, is well equipped; many American railways being content with 50 per cent.

In Great Britain a very common form of engine-house is the *longitudinal*, with parallel through tracks, and exit at both ends. Their capacity varies, rarely exceeding 80 engines. The roof is usually of the saw tooth pattern, a series of narrow spans, supported by hollow iron pillars, forming conduits for the water from gutter in roof valley, to under ground drains. The roof is hipped unequally, favourite angles being 60° and 30°, and that side more nearly vertical is glazed with ⅔ inch rolled or rough plate, and if possible is arranged to face north, so as to give a good light equally diffused throughout the wide building, without too much inconvenience from the direct rays of the sun. Snow and frost prevent the saw tooth roof being used in Canada, (the Author not knowing of a single example on this continent north of the State of New Jersey,) hence our roofs are of single slope ("flat") or single ridge of quick pitch, and as skylights have but a partial efficiency, the necessity for securing light from the side walls limits the width of a longitudinal engine-house.

An excellent example of this type of house built by Mr. H. Wallis at Point St. Charles, is 76 ft. wide by 282 ft. long, with five parallel tracks through it, giving liberal accommodation for 25 long tender-engines. Any increase in capacity, could only come by lengthening the building and tracks, which increases out of all ratio the difficulty of working the longitudinal type of house. This difficulty is the trouble and extra movement of other engines necessary to get a locomotive out and ready for service, should one on the same track in front of it, be undergoing for a few hours such light repairs, as the renewal of truck wheels, that prevented it from being moved until the work is completed. American criticism says that this is the main defect in the longitudinal type of house. It does not, however, in daily practice prove to be as awkward as it looks, if definite tracks are reserved for such repairs and for such

engines as have to keep "shed-day" while their boilers are being washed out, and if the house-men (engine turners) learn what part of the house each engine should go to, before attempting to put it under cover.

Exit at both ends of such house, cannot be obtained where the yard room is limited. At Cardiff on the Taff Vale Ry., Mr. Riches, being compelled to have one end of his new engine house blank, put in the middle of its length a traverse pit and table, crossing its ten tracks and then passing out (through pocket on side wall) to parallel siding in yard. This gives practically three exits, with exceptional economy in space. (See Proceedings Inst. C. E., Aug., 1884, p. 243.)

The Great Western Ry. of England (see Drawing No. 1) has in many of its engine houses, combined both the longitudinal and the radial systems under one continuous hip and valley roof, and the North Eastern Ry. (see Drawing No. 2,) had so great an affection for the radial system, that five turntables were put under one roof, 280 ft. wide by 450 ft. long, giving stallage for 95 engines. This is an extreme case and is probably unique, although in passing it may be noted, that the late Howard Fry, in designing the extensive workshops for the West Shore Ry. at Frankfort, N. Y. (see Drawing No. 3,) laid them out so that the smithy, boiler-shop, foundry, erecting and machine shop stand radially to an open turntable. Having, however, unlimited land at his disposal, the tracks from the outer ends of these buildings were connected by easy curves to the yard sidings, so that a failure of the turntable or the blocking of its pit, does not necessarily lock up all entrance to these shops, such being the case with the tracks in an engine house, which converge on a central turntable as their sole means of exit. The B. & M. R. Ry. at Plattsmouth, Neb., also has most of its shops in the shape of segments of an annulus centering on one turntable. An exceptional type of engine house was to (and probably may yet) be seen at Baltimore, O. A narrow strip of land laying parallel with a curved main line, was utilized by taking off with quick curve, an independent siding for each engine stall, the straight portion—one engine length—at its end lying at about an angle of 45° , with a tangent from main line at the switch. Each stall had side walls with arched openings, a blank wall at back, and an independent gable roof, (giving the general outside effect of a ridge and furrow roof) and each of the entrance doors stood in advance of its neighbor—or in echelon.

This illustration is of interest only as showing how a long and narrow strip of ground—where land is dear—has been conveniently adapted for locomotive storage.

The best radius of track curve is an unknown quantity, but the N. Y. C. Ry. safely uses as quick as 160 feet radius for their city freight house.

The Author would strongly endorse the longitudinal type of engine house. It is eminently serviceable where a large number of engines have to be turned out almost together at the busy portions of the day. An English officer, daily handling about 400 train engines at one terminal, in comparing the two systems, said, that if turntables controlled the exit of his engine houses he believed it would be impossible for him to get the engines out on time for their trains, even with additional space and men placed at his disposal.

And this type as readily suits small establishments. An engine-house recently erected by Mr. H. Wallis at Lindsay (under the supervision of the Author) is 250 by 62 ft. It has two through tracks, with continuous ash-pits for 10 running engines, one through track for engines under repair, being washed out, or waiting under steam between trains; and parallel with the windows of one side wall, are two stationary boilers with overhead apparatus for sand storage and drying, three smiths and other fires, a stationary engine, a force pump with underground water supply tank, and still continuing in line with the shop and main shafting, are wheel lathes and other iron working machinery, the fitters' benches, and the wood working tools and benches, followed by foreman's office, clerks' office, and a two storied storeroom, with oil tanks below ground, the whole resulting in a cheap compact arrangement, every foot of floor space being used, while every corner and detail is well under the eye of the foreman. The tracks in yard form a triangle (or V, as it is called) and a turntable, and its pit is dispensed with thus getting rid of one source of probable failure and delay in getting engines out "on time."

Many engine houses are now equipped with a continuous pipe $1\frac{1}{2}$ inches or 2 inches diameter, having branches to each stall and flexible couplings to each engine. Its uses are various. The steam and water from a boiler to be "blown off" and washed out, is sometimes used to heat the water with which the washing out is to be done, it is occasionally passed into a boiler of cold water, so as to shorten the time in raising steam after a washed out boiler is refilled, and sometimes, it is connected with the jet-blower at base of locomotive chimney, and the steam used in creating a draft to quicken up the newly lit fire. The two latter arrangements prevail where an injector or inspirator is used to give the washout water pressure.

OIL HOUSE.

A special feature of American engine-houses,—the outcome of the extensive use of mineral oil for lubrication as well as for light—is a detached oil house; a fire-proof brick structure with iron roof, roof covering and shutters, and concrete or asphalt floor. Underneath it (below track level) are iron storage reservoirs, with inlet pipes so arranged

that oil received in bulk can gravitate from the tank-car into any one of them, from whence it is lifted by hand or steam pump into small tanks on upper floor, and drawn thence by tap for engine and train use.

The concrete floor is at level of car-floor, or about 4 ft. 2 in. above rail level, to facilitate small shipments to out-stations, which in the more perfect equipments is by means of circular iron tanks holding 60 gallons. The cellarage around storage tank and the house, is warmed by steam pipe from outside, and the artificial light is gas, or as at Indianapolis electric,—no lamp or torch being admitted.

SAND HOUSE.

The sand used to increase the adhesion of locomotive wheels would at first sight seem to be too small an item to require specific attention; but eight or ten tons is a daily issue at central stations. At Columbus, O., the sand store, having a capacity of 1,000 tons, is a neat wooden building with hinged shutters at top of walls, set so as to permit the air to assist in sand-drying; and the floor is of dry brick set on edge, with tile drain below. When required for use, the top layer of sand is shovelled into hoppers, containing fine steam pipes one inch diameter sand spaced two and a half inches apart; when dry it falls through bottom opening into a concrete floor.

The G.T.R. has recently, by hand power belt and bucket elevators, lifted the dry sand into overhead reservoirs, from whence it is allowed through hose and molasses gate, to deliver directly into sandbox on top of locomotive boiler.

COAL SHUTES, ETC.

Equipment for coal delivery to Tender may be passed over (the author having treated on this matter at large elsewhere), also the details of water supply and delivery, as the varying local necessities do not permit any uniformity in this matter.

GENERAL REPAIRING OR ERECTING SHOP.

The amount of floor space to be devoted to the general repairs of locomotives and tenders, and its proportional division among the various buildings, is a wide question, on which little has been written; and in attempting to find an average taken from existing practice, difficulty is experienced, due to so many workshops manufacturing supplies for out-stations and for other departments, even when not manufacturing new engines.

Simply for repair purposes, the Author is of opinion that there should be floor or stall room in the erecting (repair) shop for 10 or 11 per cent. of the total engine stock. It may be expected that 4 or 5 per cent. will be in the paint shop going out, or in yard waiting to come in to erecting shop for general repairs, and that 5 per cent. are having their boilers washed out, or undergoing running repairs of so trivial a nature, that they can be done in the engine house. This leaves 80 per cent. of the motive power effective and at work daily.

To illustrate—we will suppose the total number of engines on a railway to be 100; the working engines make a daily average of 133 miles or 4,000 per month, which multiplied by the 80 effective engines gives 3,840,000 miles per annum, and the repairs done in the erecting shop have to balance the wear and tear of this mileage.

The first question is one of time: How long does it take to repair an engine? An average common in America is—

Heavy repairs occupy 90 days—equivalent to a wear of 100,000 miles.
Medium " " 60 " " " 70,000 "
Light and specific repairs occupy 30 days—equivalent to a wear of 30,000 miles.

General average is 60 days (2 months) to a wear of 67,000 miles.

Each engine on a general average, occupying a stall for two months, gives the output of repaired engines for an erecting shop containing ten stalls as 60, which multiplied by the average mileage of 67,000 totals to 4,020,000, a sum just in excess of the mileage during the same period by the 80 effective engines.

There is (or should be) some relationship in size, between the erecting and other shops of the locomotive department, and Table No. 1 Appendix A. gives from recent practice the comparative area of the other shops in percentages of the erecting shop.

You will note that the proportions do vary; and it must be so when some establishments build more or less new work, while others are restricted to repairs only; some are confined to locomotive work, whereas in others material is manufactured for all departments, including even the telegraph department.

Also the "size" relationship will be varied by the uniformity and interchangeability of the parts of the engine stock. Where their classes and styles are few, the smithy and machine shop will be comparatively small, and the delay to engines in the erecting shop comparatively shorter. Thus any such Table will only permit of a mean average being taken.

This being the case, under each heading is a second column, in which the size of each shop is given as a percentage of the whole—so that, given the total roofed surface that can be devoted to the locomotive department, its proportionate divisions can be approximately inferred.

Showing the relative area of railway shops for locomotive department. The first column gives the percentages in comparison with the erecting shops which is taken at unity (100); and the second column the percentage of the total roofed area devoted to locomotive purposes.

KIND OF SHOP.	Harrisville, N. Y. & W. R. V.		West Reading, Tonawanda & W. R. V.		Scranton, Erie & W. R. V.		Indianapolis, G. & W. R. V.		Chicago, C. & N. W. R. V.		Hawthorn, Erie & W. R. V.		Waterville, W. & C. R. V.	
	Percentage of erecting shop	Percentage of whole	Percentage of erecting shop	Percentage of whole	Percentage of erecting shop	Percentage of whole	Percentage of erecting shop	Percentage of whole	Percentage of erecting shop	Percentage of whole	Percentage of erecting shop	Percentage of whole	Percentage of erecting shop	Percentage of whole
Erecting	100	29	100	257	100	34	100	14	100	13	100	23	100	37
Machine	100	29	180	223	61	21	166	21	200	20	241	10	210	35
Boiler	50	14	41	15	44	15	111	15	72	11	221	9	18	6
Smithy	43	12	63	15	44	15	178	25	110	16	13	5	29	1
Tender					23	8			72	11				
Tool room														
Engine and boiler house	29	7	10	21	16	5	29	4	15	9			11	4
Stores			85	29	3	1	106	13	55	9	17	6	30	10
Office	29	8									21	9		
Flue, copper and tin							55	7	36	6				
Foundry (iron)											13	5		
Paint											14	5		

* Starred items give area of combined shop for car as well as locomotive department.

In America the ordinary arrangement for erecting shops is, that the pits or stalls lie transversely to the main axis of the building, admission to them being by a transfer table or traverser, within the building in northern latitudes, and outside it where snow is likely to cause but little inconvenience. There is an obvious economy in size and cost of structure when traverser can be put outside; but its free movement cannot be insured during a Canadian winter, and an attempt to use one in Montreal was, after much inconvenience, abandoned years ago. Hence the shop must be wide enough for its work, and for the length of the traverser in addition, at once giving a span of roof justifying the use of intermediate supports; and two rows of pillars are often used, dividing the floor space into three bays, one on each side of and parallel with the traverser pit, as this brings the work and men close to the side windows. When the traverser is outside it is rarely that the floor is obstructed with more than one line of pillars. Whatever be the number and disposition of these internal supports, the roof is invariably of the single ridge, or gable pattern (see Drawings Nos. 7 and 8.)

TRAVERSERS OR TRANSFER TABLES.

It was due to traversers being framed in timber that the pits in which they moved were at first so deep—even exceeding five feet. Rolled steel is now used for the frame, which is suspended from the axle journals on both sides of eight small wheels, and for which four parallel rails are provided, the full length of pit. Much ingenuity has been used in the endeavor to reduce the inconvenience of the pit, by making it as shallow as possible, and at Reading, the Philadelphia and Reading Railway in its new car shops has no pit, only a flush asphalt floor from wall to wall. As, however, the suspended or carrying rails of the traverser must be higher than the fixed rail over which they move, it is arranged that the tracks at each repair stall, instead of being spiked to cross-ties, are carried upon longitudinal timbers about 10" square, thus lifting them above the floor level, and giving the necessary difference in height between the traverser bed-rail and its suspended rail. The author is not familiar with any illustration on this Continent, of the European practice of making bed-rails for traverser and the transverse or stall tracks, flush with each other and continuous, except where slightly cut at intersection to allow the wheel flanges to pass. The shallow rails on the traverser only just clear the bed track on the floor, and the vehicle to be transferred mounts to them by running up tapered extensions of the suspended rail that are hinged—or rather pivoted—on its ends, and which when not pressed down by the wheels of the on coming vehicle, are kept clear of the bed tracks by springs. This practice may be said to be a development of the "Dunn

Traverser," at one time in common use for the transfer of carriages at terminal stations on English and Continental railways.

Having all rails flush, not only permits the rapid movement of men and small material, but allows the transfer, when traverser is engaged, of vehicles from a stall on one side of bay to the track immediately opposite. Having in view the possible failure of the traverser, some shops are, and all should be, provided with portable rails to span the width of pit.

Power to move the traverser is often communicated direct from boiler and engine carried upon it. This, convenient enough, perhaps, for out-door service, has proved to be an unmitigated nuisance under cover in winter, when doors and windows must be kept closed. Endless chains, the full length of the bed with stop and start gear at one end, are sometimes used. The friction is large, the chain having to be supported every eight or ten feet, and signals to control traverser movement have to be transmitted over long distances.

Stout wire cable, travelling at same speed as chain, offers less resistance, and if one of the forms of clip gear is used on the traverser, the single attendant travelling with it has its motion completely under control. The clip gear (cable grip) used at West Albany, N. Y. C. Ry., is a simple form of friction brake stopping the revolution of a set of three geared wheels. When locked, the traverser moves at same speed as rope. Two sets of such wheels are used, so as to give both up and down motion. When table is at rest, power is transferred to a capstan used in hauling vehicles on and off the traverser. At Alton, Mr. W. Wilson causes a small quick moving rope to give motion to one wheel and shaft, from which power to traverser and capstan is communicated through level friction wheels. Speeds of traverser is slow, 25 ft. per minute, and that of the capstan is but 32 ft. per minute.

The outdoor traverser, built some years ago for the Wason Car Shops, Springfield, is 50 ft. long, and weighs 11 tons, being propelled by a boiler and engine of 12 N.H.P. A steam pressure of 15 lbs. will move it without load; 30 lbs. with heaviest passenger coach on, and 60 lbs. gives it a speed of 500 ft. per minute.

An interesting and successful attempt has just been made at Aurora on the C. B. & Q. Ry., to give motion to a traverser and capstan through an overhead electric wire with a small trolley running on it connected to a $7\frac{1}{2}$ H. P. Sprague motor. Its rapid motion is geared down, so that table can be run either at 100 or 200 ft. per minute. The table is 65 ft. 9 in. long by 15 ft. wide, and weighs empty about 15 (short) tons. The tractive resistance, unladen, is about 250 lbs., equal to 17 lbs. per ton; loaded, it is 1500 lbs. or 37 lbs. per ton. Experiments on the Cohn Menden Ry. at Deutzerfeld give the resistance of a traverser and load weighing 20 tons at 440 lbs., equal to a tractive resistance of 22 lbs. per (long) ton.

Cotton ropes moving at 3360 ft. per minute, are used (under cover) at Cologne on the Rhenish Ry. for coach traverser, friction clutches being used to change the speed, so that the table has a motion of 197 ft. and capstan of 64 ft. per minute.

Erecting shops equipped with traversers at low level, need in addition, some means of lifting an engine off its wheels, and a hoist is usually fixed in the roof timbers either close to entrance or in centre of length of shop over the traverser bed. Lifting power is variously communicated to hoist by belt from shop shafting, by hydraulic pipe, by pneumatic pipe, and even by hand labour.

OVERHEAD TRAVELLING CRANES.

The European practice of making the erecting shop narrow compared with its length, using three (or at most four) longitudinal tracks and spanning them for their whole length with overhead power travelling cranes, has not often been adopted in America, although we have specimens at the C. P. Ry., Montreal, Altoona, West Burlington, Indianapolis, Roanoke, and Hamilton, Ont.

Why so effective a method has been comparatively neglected, it is not easy to say, as by its use there is an economy in floor space, and the cranes can do duty for both traverser and hoist. Undoubtedly the roof, or a portion of it, must be carried up higher, so as to give head room for the cranes and their load to pass over engines being repaired; but the interest on this outlay and on that of the cranes (usually exceeding the cost of both traveller and hoist), is but a fraction of the money and time saved in the daily working of the shop.

Two fish-bellied plate girders, extending from sidewall to sidewall, with their ends supported on plate box trolleys, usually form the crane bed and carry on—or better still, two—travelling crabs. An independent boiler on crane—is a source of power—is now rarely used, but from the shop shafting motion is communicated to the crane by quick moving rope of steel wire, hemp, cotton or rawhide. If the distance crane has to travel is short,—say under 150 ft.—or if it is used in the foundry where heat and dust would materially shorten the life of a fibre rope, then longitudinal shafting (grooved or square), supported on tumbling bracket journals, is often used. In almost all cases where the winch forms part of the trolley, the transfer of motion to it from the end of crane is by such a shaft, although in the original cranes of this class designed by Mr. Ransbottom the high-speeded cord was carried along the crane girder through the trolley to opposite end, and then back to side wall, bending the cord often and shortening its life.

Messrs. Fowler of Leeds use steel wire rope similar to that used in steam ploughing, their 12 ton crane being equipped with a $\frac{3}{4}$ in. diameter rope, moving at 270 ft. per minute. One, of 40 tons capacity and 50 ft.

span, has the rope speeded to 400 ft. per minute, giving a slow lift of 2 ft., and a fast one of 4 ft. per minute, with a cross traverse of 28 ft., and a longitudinal motion of crane and load of 30 ft. per minute.

A 20 ton crane, using manilla rope of full $\frac{7}{8}$ in. diameter, running at a speed of 2540 ft. per minute, has a slow lift of 3 ft., and a quick one of 51 ft. per minute, with a cross traverse of trolley carriage of 16.8 ft., and a motion of the whole crane of 47.5 ft. per minute. It has the hoisting winch at one end, thus permitting the use of a 45 ft. span single box-girder partially open below, the trolley carriage travelling inside the box on the angle irons forming the lower web.

The seven original Ramsbottom cranes at Crewe used long fibre cotton rope $\frac{7}{8}$ in. diam., weighing $1\frac{1}{2}$ oz. to the ft., having a tension of from 17 to 18 lbs. and a speed of 5000 ft. per minute. Larger diameters, lower speeds, and cheaper material, are now used, as at Swindon where $4\frac{1}{2}$ in. rope at 970 ft. per minute is employed. Messrs. Penn have used raw-hide rope moving at 1,500 ft. per minute; and a 50 ton crane used on dock has had five years service, without showing any wear on raw hide rope of $1\frac{1}{2}$ in. diam.

At Aurora and Altoona, cotton rope with speeds of 5,000 ft. per minute are used, giving with the 25 ton cranes of the latter, a slow lift of 15 ft. and a quick lift of 81 ft. per minute, a crab traverse of 30 ft., and a crane travel of 50 ft. per minute.

The two cranes at Alton (see Drawing No. 7) have each two crabs, so that the engine is suspended and independently moved at the four corners, a decided convenience when dropping frame and boiler on the wheels.

Where possible it is an advantage to put the crane attendant's platform below the main girder and close to the wall, so that the work below and not the crane machinery is in his view.

Pneumatic floor cranes for light weights, although not common, are used at Wilmington on the P. W. & B. Ry., and at the Paige Works, Cleveland. The Missouri Pacific Ry. uses compressed air at from 60 to 80 lbs. pressure, to work small three cylindered Brotherhood engines for giving motion to boring valve facing and other portable machines, the air being compressed by a Westinghouse brake pump and distributed through small pipes. In the engine house, or in the shop after ordinary working hours, such portable motors can by rubber hose be coupled either to the air pump or the boiler of the nearest locomotive in steam.

The pneumatic transmission of energy is not in itself economical; but for the small powers used it is far cheaper than shafting and more rapid than using manual labour to the work.

At Scrating all classes of shop cranes are pneumatic. The reason for this practice is that with the large area under continuous roof the volume of pure cool air exhausted is of value in assisting ventilation and increasing the general health of the workman.

Our shops, sheds and freight houses are rarely designed with the object in view of reducing manual labour in lifting, and many of us feel the regret expressed by Mr. Don J. Whittemore, ex-President American Society of Civil Engineers, "I could not prevail on our people to make use of cranes to the same extent used in England, and in this we are at fault." As an after-thought, pillar and other fixed cranes are occasionally applied, but their value and efficiency is limited, and for equal outlays, by far the most economical results follow the use of movable cranes. Hoisting by unskilled labour is one of the most expensive parts of the old fashioned plant which American shops yet retain. Recent experience in the use of hydraulic droppits for removing single pairs of wheels (although with all its advantages an inelastic convenience) provokes such strong commendations and approval as a labour and time-saving machine, that it must be that the period is not far off when overhead power lifts shall be common in our shop equipment. The wear on the metal work of cranes is not rapid, and an allowance of five per cent. per annum on first cost, covers all depreciation, except in the matter of lifting chains which require care and frequent testing. With economical results, wire rope has replaced lifting chains, its only defect being an increased diameter in pulleys and drums, the increase not being excessive (about 25 per cent.) as the speeds are slow.

To support an overhead travelling crane track the plan usually adopted is, to increase the thickness of the brick side wall pilasters, and arch over the window and door openings flush with pilasters up to elevated track level, thus securing a solid safe support for crane travel, with the disadvantage of materially reducing the width inside shop and the window openings. Rolled iron (bolted to the walls) both for pillars and girders would to day be the better practice. A good arrangement is to use stout cast iron pillars to support both the crane track and the roof principals, filling in between them with walls of just sufficient thickness to keep out the weather. It is difficult to use a single section of wrought iron for this double service, as the support for track must be bolted on its side, and the weight from the crane is not then brought directly over the foundation, resulting in a tendency to throw the heel of the pillar outwards, and put the roof principal into compression. By using cast iron pillars, and varying their shape at the upper end, there is no difficulty in bringing the crane weights vertically onto the underground foundations. The Author is not familiar with any example of a cast iron pillar doing such double duty in any northern climate.

TRANSMISSION OF POWER.

In power transmission throughout workshops, small shafts, light pulleys and high speed flat leather belts are common in, and belong properly to,

America; but there is a growing tendency to dispense with shafting in favour of rope, and to use hemp or manilla rather than wire rope. Examples of the use of wire rope are to be seen at Altoona, St. Paul, Proctor, and the B. N. Y. & P. Ry. has run its machine shop 312 ft. distant, with $\frac{1}{2}$ wire moving at a speed of 6,300 ft. per minute, for two years without repair. At Columbus, motion is transmitted by hemp rope moving at 1,500 ft. per minute, and Mr. Drumond at Cowairs uses rope throughout, even for transmission at right angles,—circumstances under which the G. T. Ry. prefers the use of V leather bolting. Satisfactory instances of the use of hemp rope between engine and main shaft may be seen in Montreal at the C. P. Ry. shops, the G. T. R. shops and the Redpath Sugar Refinery. A rope 2 in. diam. moving at 3,000 ft. per minute will transmit 25 H. P.;—that is, with a duty equivalent to a 4 in. belt moving at the same speed. Three ply manilla rope is better than four ply. The pulleys should be at least 30 times the diameter of the rope, and the shafts not less than 20 ft. apart; angle of groove in pulley rim 40° , the rope not being allowed to bottom in groove as in the case of wire rope. Some actual tensions are as follows: a manilla rope $6\frac{1}{2}$ in. in circumference, with a speed of 2,972 ft., transmits 23 H. P. with a tension of 256 lbs., another at 3,782 ft. transmits 40 H. P. with a tension of 349 lbs., a third has seven ropes of $1\frac{1}{2}$ in. diam. at 2,355 ft. transmits 34 H. P. with tension of 476 lbs., the tendency with increasing experience being to increase the tensions, which are still far below those used with iron and steel wire ropes. Hemp apparently suffers little from climatic influences and its life especially at the weak point—the splice—may be lengthened by coating it with beeswax and a little plumbago.

The Southern Railway of France has probably made the most complete application of hemp rope in the minute division and transfer of power. The through shaft in shop is provided with numerous V pulleys by which motion is given to three-quarter inch hemp rope, so that at every point in shop, power may be delivered to light overhead cranes as well as to numerous specially designed portable machine tools. For instance, in the boiler repair shop, not only are the drills so worked at any angle or in any corner; but the holes are tapped, and the screwed stays put in, much in the same way as similar work is done to a limited extent with the Stow flexible shaft.

Electric transmission has been used in Germany for some years under restricted conditions. It has some advantages, as the conductor is less clumsy than shafting, steam pipe or rope, its position can easily be changed, and the motor is compact and less of a nuisance than a small steam engine. Loss of power there certainly is, but not much in the actual transmission between points far apart, if wire of reasonable diameter is used, and the less the power being taken off, the less is the percentage of loss in the transmitter, the opposite rule holding good with shafting. The chief loss is in its use of double machinery, the first to convert motion into current, and the second to reconvert current into motion. Every month is simplifying the problem and minimizing the waste; and the ready adaptability of electro-magnetic machine tools (without intermediate machinery) to the varied purposes of drilling, tapping, rivetting, chipping and caulking thick steel ship plates in position, their high duty and rapidity of work, are shown in the paper by Mr. E. A. Rowan recently discussed by the Institution of Mechanical Engineers (see Proceedings, Aug., 1887), in concluding which he expresses his belief "that it will be found both economical and otherwise convenient to adopt electrical distribution in engineering workshops, instead of the existing system of shafting and belts, or even hydraulic distribution of power."

Transmission of power by steam pipe and independent engine for each shop has up to date not been common in countries liable to low temperature. In mild climates, the use of separate wall engines with the cranks coupled direct to shop shafting is most satisfactory, and a pair of locomotive cylinders are often used for such service, as the engines occupy little if any floor space when set vertically, and each shop can be run independently when it is necessary to work it overtime. In America the use of the Westinghouse engine for such service is increasing. This plan is simply an extension of the practice common in many large ship yards of giving an engine (in some cases even a boiler) to each group of five or six large tools.

With the use of modern asbestos and silicate coverings, there is but little loss by condensation in the long steam pipe. Mr. W. T. Bird in his careful experiments (see North of England Institution of Mining Engineers. Proceedings 1882-3) has shown that the condensation in an exposed pipe 1,000 ft. long is sufficient to reduce the steam to 76 per cent. of its boiler efficiency, and coating the same pipe with silicate cotton raises the efficiency to 95 per cent.

MACHINE GROUPING

At one time the endeavour in arranging a machine shop was to group the large machines close together, so that the heavy and bulky material steadily progressed from one to the other without retracing its path. With the adoption of light overhead cranes and single rail tramways for moving heavy weights, the rebandling of raw material has lost much of its importance and most of its expense, so that the favourite arrangement is to mass similar machines of all sizes close together, permitting one skilled man to be put in charge of the whole class. An alternative—when a charge man is not employed—is to put one skilled attendant to each pair of such machines. However, the main advantage is that the whole floor space can be more fully utilized when machines of a class are massed, than when different machines of about equal size and capacity are grouped together.

When small machinery is placed on a narrow side gallery, it is better (if window light will permit it) to locate a double row of machines back to back in the centre of the gallery, thus leaving a narrow passage on each side, rather than to put them in two lines with the passage between them. This grouping the better enables each attendant to keep his raw and finished material separate from his neighbors, and there is less countershafting needed. Its one defect is that it brings the attendants—usually boys—close together and face to face. Mr. W. Wilson has this arrangement of lathes on ground floor at Elton (see Drawing No. 8.).

The solidity of machinery designed for railway shop service permits tools with single cutters to take wide and deep cuts, and in milling machines permitting a much higher speed at cutting surface (and by virtue of which they are rapidly displacing shapers, planers and slotters), the actual depth of cut has little influence on the cutting speed; hence, it has been found at the forge not economical to smith too close to size. This refers, of course, only to hand work. All wrought iron stamped or worked out under "formers" should, for several reasons, be made close to size.

The most complete description of American machine tools the Author has seen, is an illustrated appendix to the 10th Census Report U.S.A. Having the most favorable opportunity for securing such useful information, the compiler has, apparently with set purpose, neglected to give the linear advance (cutting speed) for a single tool. Had this information been given, it would have more than doubled the value of the report. The best speeds and angles for cutting all metals is a large subject upon which our recorded information is meagre.

Whether the merit is deserved or not, it would be difficult to say without material for a wider induction, but many master mechanics in America do claim a higher cutting speed, a greater uniformity in tools and their sharpening, and a better toolroom and toolroom system than is common in Europe. Certainly ample space and high paid skill are devoted to the toolroom in all new western railway shops.

FOUNDRY.

Foundries for the production of iron castings rarely form part of American railway equipment, yet no shop returns a larger interest on the capital invested, is more useful in the rapid despatch of daily work, or more helpful in case of emergency. That these benefits may be realized, its design and details should not be fortuitous, even if many of them now in daily service suggest the inference that, like Topsey, they "grewed."

Many years service—as well as recently erected shops—show that a most convenient plan is to divide the surface to be roofed over, into two sections of about equal length and span, placing them at right angles to each other, with the cupolas in the inner corner as the most central position without occupying floor room; the square of open land behind the cupolas being utilized for the storage of scrap iron, fuel, &c. The foundry at Pt. St Charles is practically based on such a ground plan, although an existing building was utilized for the purpose. (See Paper by Mr. F. L. Wanklyn (Member) in Proceedings Inst. C. E., vol. 88, part 2).

Overhead travelling cranes are preferable, so that the molten metal will not need transfer from one crane to another; but if job-cranes must be used, one set in front of and between the two cupolas will swing into both sections through an arc of fully 270°. The sand stores, core ovens, &c., being set close to inner wall, light is received through windows in the long outer walls.

A model foundry recently completed by the Pittsburgh Locomotive Works is shown by Drawings 9 and 10. Mr. D. A. Wightman, the Superintendent, says one of its peculiarities is the location of the core oven and core room, which are placed below the level of foundry floor, the top of the core ovens being on a line with said floor, and the runways—used by trucks out of the ovens—are covered, all except a hatchway left open for dropping the heavy dry sand cores and moulds down with a crane.

The core room is on the same level with the core oven floors; but is left open at the top of the foundry roof, and receives its light from the main windows of the building. Communication between the core room and the south side of the core ovens is had by means of a passage way under railway track. The sand pits all open out of the core room, and have manholes outside for shoveling the sand through from wagons and cars.

This arrangement of core ovens was suggested in trying to obtain suitable light, as on one side at least nearly all foundries have their light shut out by core rooms, core ovens, and cupola house. The plan adopted obviates this difficulty, and you will probably conclude after examining the drawings that this building has better light from the ground than any foundry you have ever seen.

The sand conveyer indicated on plan, is simply a Gandy Belt, placed beneath the surface of the foundry floor, upon which the sand is thrown, from any point where it may be lying, and conveyed to an elevator which delivers it into a revolving screen, thence falling into the hoppers over the moulding machines, which are kept fairly full, so that upon opening them at bottom, the flasks are filled very quickly. The conveyer saves the labour of wheeling the sand up to and shoveling it into the moulding machines. One man takes care of all the sand for the two machines, whose output in castings varies from 5,000 to 12,000 lbs. per day.

At Seraing—even for small work—each moulder is provided with an iron table, so that he can work in a standing position.

An effective, well ventilated and therefore healthy brass foundry is that at Altoona; a square, single-storied, semi-detached building, with the windows, moulder troughs, and core benches on the three open sides. A circular chimney is in the centre, having around it a ring of crucible furnaces below ground level. This arrangement requires separate core ovens on face of blank wall, an expense justified where the output is large. In smaller foundries the furnaces are in line in front of a blank wall, the flues between furnace and chimney passing around the core ovens, the chimney being supported on iron girders, six or seven feet above floor level, so that any portion of furnaces, ovens or flues may be renewed without disturbing or weakening the chimney.

A convenient location for the foundry is a position in which its blank wall can abut against, and have a door opening into the stores building, so that the transfer of raw metal in, of finished castings out, and the book keeping this requires (if any effective check is to be kept on the use of such expensive material), is simply and cheaply done.

SMITH'S SHOP.

The smithy used to be a narrow shop, with the fires ranged close to the side walls and an open central passage. This arrangement has been modified, as the large machinery which is displacing hand work is most conveniently set in line down the centre, with a passage on each side of it—that is a track between the machinery and each line of fires; hence smithies have increased in width from 40 to 60 ft. and over. Certainly the smith does not need much window light, yet he should not be made to stand between his work and the window when at the anvil, as is done when the fires are set at right angle to the sidewalls. The better plan, which has long prevailed at Sir W. Armstrong's works and elsewhere, is to group them in pairs set parallel with the wall.

A recent experimental attempt to draw off the forge smoke through underground flues by the natural draft of a 140 ft. brick chimney was not successful (whatever may be the result with higher and costlier chimneys). The most complete way of doing this, as at the Valley Falls shops P. & W. Ry., is to connect the smoke stack of each fire with a central smoke flue running parallel under ridge of roof, providing it at outlet with a suction fan blowing into a short chimney, whose draft it improves. Brick hoods and smoke stacks make a permanent arrangement when each fire or group of fires has a separate outlet; but if the building is to be kept fairly clear of smoke, movable sheet plate hoods are needed.

For ventilation small flues from outside, passing through dwarf brick pillars about two feet above floor level, with horizontal gratings under control, opposite each man, are effective for admission of air, the smoke stacks or movable louvre boards in clerestory on roof being trusted for exit; neither are satisfactory in low temperatures unless the smoke flues have induced draft.

Pressure blast for fires should be distributed in overhead galvanized pipes, with a branch down to each set of hearths, and provided with hinged collapsing valves that freely fall open inwards when there is no pressure in the pipe. This simple device prevents any inflammable gas from accumulating in the mains after the fan is stopped, thus avoiding explosions when lighting up.

There are elaborately equipped smithies with elevated trestle track outside the wall from which the fuel is delivered through sheds to the forges; however as this track is not available for the delivery of the metal or the removal of ashes or forgings, its value is not great, and trolley tracks on each side of steam hammers at floor level are ordinarily considered sufficient.

The number and variety of steam hammers is increasing, and as the interest on the cost of purchase and foundation of the handier sizes, does not amount to the wages of a striker, and there is no comparison between the relative usefulness and productive value of the two, each new smithy is likely to have a larger number. The points in the setting of steam hammers worthy of note, are:—that the foundation for standard and for anvil must be kept quite distinct, that solidly bolted timber on end, makes one of the best supports for the anvil block, and that as no foundation fully absorbs the throb of a large hammer, the forge and smithy should be removed as far as possible from the shops holding tools of precision, but not removed beyond reach, by a standard gauge track siding with some yard room near to store scrap, fuel and the steel dies, or "formers" that accumulate around a well used hammer. The foundations and relative grouping of bolt, nut, link and pin forging machines, spring making and shearing tools with tube welders and metal saws, cannot at present receive any attention.

BOILER SHOP.

The boiler shop in all satisfactory works is detached, so that the noise of hand rivetting (not yet completely dispensed with) may be as little of a nuisance as possible. In height and width it is often a duplicate of the erecting shop, but with flush floor. It is worthy of note, that some works on this continent not using overhead travelling cranes in the erecting shop, appreciate their usefulness so far as to equip the boiler shop with them.

The hydraulic and other heavy machinery for handling thick plates is massed at one end, and the lighter equipment for thin plates and tender tanks at the other end of one side of the shop, the floor on the other side being left open for actual construction or repair. The plate furnace (with forced draft) is set, so that its flue may have a short run to the chimney erected for the forge or smithy, and set close to the heavy flanging tools.

Standard gauge as well as trolley tracks cover the floor and the plate store (or rack) is close to main track and to furnace.

Accommodation should be ample, as the boiler shop—most managers find out—is one of the least flexible of shops; therefore it is wise to give it space and a full equipment of modern tools.

FLOORS.

European practice in flooring, varies from wood block on solid foundation to plain block and plank, using clinker, hard packed cinder or clay in smithy, and for paint shop, concrete or asphalt. The German Railway Union recommend stone or tile—except where men stand at machines, and here wood should be used. Slate gives—all things considered—the best service and wear under foot, of any known substance, and being light, strong and durable can be strongly recommended for stairs and steps. The continuous concrete floor used at Columbus, has for its first course, six inches of broken stone, for its second, eight inches of finely broken stone mixed with cement, and for the finishing course, a compound of Portland cement, asphalt, and sand, four inches deep, which being slightly elastic, is not readily cracked by a sudden blow.

South and west of Pennsylvania a solid floor is made by rolling the earth, and then bedding, about thirty inches apart, half round locust stringers in four inches of concrete, before it sets hard. The stringers are floored with two inch Georgia pine plank coated with hot tar. Oak flooring is often used in that neighbourhood, not because it lasts any longer than white pine, but because it is cheaper in the local market. The Georgia Central Ry. coats the sills with resin, packs the earth up to within half an inch of their top, spiking the planking down after boring holes through it; resin is then run in through these holes until the whole cavity is full, thus completely isolating the timber from the damp earth. In Canada a cheap floor for light weight is made by bedding half round cedar in a foot of engine cinders, and nailing two inch pine plank on top.

Sellers of Philadelphia, uses under his machine tools a continuous iron floor resting on brick foundation walls, and between the machines, pine plank for the workmen to stand on.

TURNABLES.

The American pattern of turntable is a "top deck" structure of cast iron up to the common diam. of 60 ft. The weight of table and load is carried on a single fixed central pyramid, with one of the many forms of antifriction cap on top, to lessen the resistance to movement. No gearing is used to give the table motion, a short lever or hand spike stands out from one end, and two men are usually sufficient to walk the table and its load around.

A fixed circular rail in the pit and end wheel trolleys at the outer ends of the girders are provided; but they come into use and carry weight only when the load is being moved on or off; at other times the table is in balance, and the trolley wheels ride just clear of the ring-rail.

When the turntable girders are of cast iron, it is advisable to dispense with any lock or catch to hold the table in line with the radiating tracks, because of the risk to the castings, if the bolt is shot out suddenly while the table is in motion;—also the enginemen will move an engine on to the table more carefully, when it is held in position by hand, than when it is locked.

With wrought iron tables these precautions are not so necessary, as they are not liable to failure by sudden side jar, but almost all wrought iron tables designed or built by dealers to their own specifications ultimately prove to be lacking in stiffness. For locomotive service, wrought iron turntables of 75 ft. diam. have been used by Mr. C. Blackwell, at Roanoke, with the object of getting rid of the frog in the radiating tracks, which tracks were of mixed gauge.

Turntables of 100 ft. diam. are invariably of wrought iron with deep side girders, the load being carried on the bottom deck, and the weight supported and moved upon small tapered rollers massed in a ring of 10 or 12 ft. diam., the whole being similar in design to the ordinary form of "draw span" in American swing bridges, and therefore not lacking in stiffness. Part of the weight must be carried on the outer ring-rail, so as to restrict within narrow bounds, any tendency to balancing on the central ring support.

The motive power is usually an independent boiler and engine, running on the ring rail, and coupled to one end of the table by drag-links or other special form of adjusting connection, so that the oscillations of the table under unequal loading shall not interfere with the adhesion of the engine on its single rail. At Roanoke the starting valve from the boiler and the reversing gear of the engine are coupled to one lever, so that a single motion controls both operations.

The pit for a side trussed table is shallow and easily drained, but as slight variations in level of support, much interfere with the ease of working, the foundations must be solidly set—that is, carried well below the frost line, and on "made" or swampy ground the weight on their base should not exceed a ton per sq. ft.

In running sand about three years ago, the author put on a central foundation for a 50 ft. table, by making a timber hollow box frame of pyramid shape 10 ft. square at base, 5 ft. square at top, and 4 ft. 6 in. deep, weighing it with rails to sink it, as hand labour excavated the material from the centre. When the top was sunk flush with level of pit, the anchor bolts passing through two 12 in. baulks, were put in place, and the whole filled in with quick setting concrete. A sand pump was kept going the whole time until the frame was filled, and the mass was finished flush, to receive the base of centre casting, no cast-iron being used.

CAR SHOPS.

The roofed space provided for the repairs of freight cars is usually limited, as twenty-five per cent. of this work can be done in the open air. The time occupied in the heaviest repair—viz., a rebuild—is short, and the detention of a car in shop is brief, compared to that suffered by a locomotive, so that a total shop surface that will shelter one and a half per cent. of the freight car stock, will be found sufficient. It is probable (if the figures could be obtained) that an average for this continent would show but one per cent., and the nearer the approach to uniformity in detail in the car stock, the less the shop room needed.

The total outdoor track space provided for repairs, change of wheels, and shop storage, is twice that under cover. There are in this matter wide variations in practice, due to climate and nature of traffic, cars moving food, clothing, &c., requiring different treatment from cars moving coal and heavy minerals.

Table No. 2, appendix B, gives from recent practice the relative area of some American car shops, the percentages being given in double columns (as explained for appendix A).

APPENDIX B.

TABLE NO. 2.

Showing the relative area of Railway shop for Car Department. The first column gives the percentages in comparison with the combined area of both Passenger and Freight erecting shops, which is taken as unity (100), and the second column, the percentage of the total roofed area devoted to car purposes.

Kind of Shop	West. Union C. B. & Q. Ry.		Comp. N. P. Ry.		St. Louis & N. W. Ry.		Chicago & N. W. Ry.		Houston & T. C. Ry.		Waterville Maine C. Ry.	
	Percentage of erecting shops	Percentage of whole	Percentage of erecting shops	Percentage of whole	Percentage of erecting shops	Percentage of whole	Percentage of erecting shops	Percentage of whole	Percentage of erecting shops	Percentage of whole	Percentage of erecting shops	Percentage of whole
Passenger Coach erecting	100	30	100	21	100	17	100	24	100	30	100	22
Freight car erecting	56	20	77 1/2	16	100	17	100	12	100	23	100	18
Paint job both	16	24	29	80	17	26	68	20	45 1/2	24 1/2	14 1/2	39
Machine (iron)	38	16	11	19	19	41	22	8	23	12 1/2	41	16
Machine (wood & saw mill)	42	17	17	10	38	13	34	12 1/2	23	12 1/2	41	16
Stores	5	2	4	7	4	2	31	11	4	2	13	10
Offices	5	2	10	4	5	2	5	12	2	1	13	10
Engine and boiler house			4	1	2	10	5	12	34	2	13	10
Dry kiln			4	1	32	10	5	12	5	1	13	10
Upkeep and Varnish					29	84	22	41	9	5	13	10
Cabinet												
Smithy												
The shop, Air												

* Includes Locomotive paint shop

* Includes Cabinet shop.

The annular form of car shop with radial tracks is occasionally used in America, requiring a turntable of exceptional dimensions—usually 100 ft. diameter—to permit not only a coach or two freight cars, but also the small tank locomotive doing the shunting, to turn upon it. A large amount of shunting is required in and about a freight car repair shop, due to the short time occupied in an average repair to a car, and the passage of each vehicle over a turntable adds both to the time and to the cost of shunting.

The supposed difficulty in utilizing the whole floor space of a longitudinal shop (and which the annular shop was designed to avoid) is the delay in taking out a string of cars until all are finished, thus sometimes keeping the workmen idle waiting for work! However, even in one of the best examples of the annular shop, that of the P. Ry. at Altoona, the radial tracks were intended to be three cars long, and therefore some sorting and dividing of cars is necessary before they can be put in, and all that the other type, with its long tracks, requires, is that this classing together of cars be done with a little more care and judgment, so that the whole string will be finished and ready to shunt out at the same time. There are good points in favour of the annular shop, if it is intended exclusively for new construction, one being the ease and rapidity with which material on trolleys is delivered close to the workmen.

However, the author would endorse the longitudinal freight car shop which is of the simplest construction, often wide enough for six or seven parallel tracks, and from 200 to 500 ft. long. The walls of brick or wood, the roof almost flat (the slope each way from middle being about one in twelve) and supported by timber posts eight or nine inches square. The posts though numerous do not seriously interfere with the work. The roof covering is cut for numerous skylights, gable-shaped and of quick pitch. Usually the floor is flush, that is, no track pits are provided, neither are cranes or hoists. The car bodies

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to be lifted being light and bulky, and requiring in many cases to be sustained after they are lifted, it is found best to use quick moving hand jacks to lift, and dogs or trestles to effectively support them, while the men do the work of repairing.

Numerous trolley roads cross the building in both directions, their union at intersection being made by cast iron turnables revolving on a central spindle. These tables may be of two castings, a base forming both pit and foundation and a revolving top with socket on underside.

This building and its contents are so liable to destruction by fire, as to justify large water pipes and numerous fire hose hydrants within it as well as without.

There is no real economy in the endeavor to repair freight cars and passenger coaches under one roof. The work is so different in character that men can rarely be transferred from one class to the other, and the dirt and dust inseparable from the cars should be kept away from the coaches. When both classes of repairs are done in the same building, it is imperative that a shop free from dust and of higher temperature be used for painting and varnishing coaches in. It is often built directly opposite to car repair shop, with a transfer table between. Here as elsewhere, entrances from both ends of a longitudinal shop is desirable, and has been obtained in many recent designs.

At the Como shops (see Drawings Nos. 12 and 13) on the V. P. Ry., each stall in the paint shop is provided with an electric call and bell, communicating through signal code with the foreman's office and the paint store, which latter building as in all railway shops, is detached, and as far as possible of fire proof construction. Often it is provided with an underground cellar for the storage of all inflammable fluid. The best practice restricts the mixing of paints and the blending of colours to one man working in this house: and in some cases the brushes and other tools used by the workmen are stored here and only issued as required. It is a "paint tool-room" in which much the same system prevails as in the "machine tool-room."

WARMING AND VENTILATION.

Paint shops need special facilities for warming and ventilation. A successful arrangement is the use of a fan to draw air through a nest of small steam pipes, and then to force the warmed air into a light galvanized iron tube, from which it is passed into overhead branch pipes and delivered through slide-gratings below, the slides being within the control of the workmen.

At Columbus the paint shop is 75 by 135 ft. containing 272,665 cub. ft., and the steam pipes have a surface of 1,034 ft., or one superficial ft. per two hundred and sixty-three cub. ft. The fan has a maximum delivery of 218 cub. ft., and has been run as high as 200 revs. per minute. The three main pipes leading from it are 30 and 24 in. diam., and the smallest delivery pipe is 8 in. diam. The air is used over and over again, and so used, it is said, without any annoyance from smell of paint. Running the fan during working hours reduces the time of paint drying by one tenth. The apparatus is widely adjustable to suit varying temperatures, as either line or exhaust steam can be turned into the heater pipes, and its amount regulated; or the speed of the fan can be varied within large limits, to which end a separate engine 6 by 9 in. stroke with steam at 80 lbs. pressure is used to give it motion. The success that attended this experiment has justified Mr. E. B. Wall in extending this system at Columbus to the machine, boiler, and black-smith shops, and the annular car repair shop. At Bloomington the new locomotive erecting shop is warmed in this manner, the exhaust steam from the stationary engine is passed into an old boiler through the tubes of which, the air is drawn and then delivered into underground pipes, the outlet gratings being at floor level.

This hot air method was in 1886 adopted for widely scattered shops at Cleveland, O., by Mr. J. Walker (see his communication to the Civil Engineer's Club of Cleveland, 13th Sept., 1887). He used a fan 10 ft. outside diam. with engine 6 by 9 in., running from 50 to 275 revs. per minute, the fan outlet being 12 in. square. With underground conduits across the yards, he finds that it requires 1 sup. ft. of steam pipe for each 100 cub. ft. of shop space, the initial air temperature when entering fan varying from 100° to 180° F. The conduits are of sewer pipe, the largest diameter of any main being 24 in., and they are trapped so as to get rid of any water that might gather. After the ground had dried there was no appreciable radiation loss from these buried mains. This arrangement permits the fan and heater to be kept within the boiler house, and the water of condensation to be returned to the boiler at a temperature averaging 180°; but the air is not used a second time, which explains the increased ratio of pipe-heating surface per cubic ft. of space to be warmed. However, the shops and foundry are kept clear of smoke, the health of the men is all that can be desired, and the system can as readily be adapted to cooling in summer as warming in winter.

Illustrative longitudinal types of coach and car shops may be seen at the G.T. Ry. works Point St. Charles, and one of the worst specimens of the circular shop, although a very showy building at Mount Clare on the B. & O. Ry. It is 235 ft. inside diam. and full 114 ft. to top of dome, yet has only space for 21 coach stalls and an inlet track.

GENERAL DISPOSITION OF SHOPS.

What may be called the typical grouping of American railway shops is to place them parallel with each other, and with their longitudinal axis at right angles to the main track (or chief yard siding), with several traverser beds and tables between them. In other words, the shops lie side by side with their gable ends facing the track.

The stalls (or shop tracks) being at right angles to the length of the buildings, or parallel with the main track, if the traversers are set in line with each other, it permits a passage from and through shop to shop; that is, it makes a through temporary passage parallel with main track.

Good examples of this arrangement are the St. Paul shops of the C. & K. C. Ry. (see Drawing No. 4), and the West Chicago shops of the C. & N. W. Ry. (see Drawing No. 5), and it has its advantages one of the chief being, that if sufficient width of land is secured, it permits extensions in length being built uniform with the existing buildings, without interfering with the ordinary railway work being carried on; and when the addition is completed, to fully utilize the added space, does not necessarily require a resetting of the machines, shafting or warming pipes, etc.

Until the use of electrically moved overhead cranes changes the shape and size of such shops, does away with the traverser, and alters their relationship to the main track, this grouping will probably continue to be adopted. It calls for the purchase of a block of land not long but wide.

One of its most prominent defects is the necessity for skylights. The side walls are so cut up by large stall entrance doors, almost filling the wall panel, that there is little space for side windows except those of limited size, framed into the leaves of the doors; also, as the door openings cannot be kept quite close and tight, in latitudes where cold high winds prevail, these numerous inlets interfere with the comfort and efficiency of the workmen. However, for a correspondingly brief period in midsummer, the doors thrown wide open are an appreciated luxury, in some measure compensating for the winter inconvenience.

So grouped the buildings are well isolated in case of fire, as not only does the width of the traverser pit intervene, but in addition there is a space of from ten to fifteen feet between wall and edge of bed, ordinarily utilized in the storage of wheels and trucks.

A neat and compact arrangement of shops built in the summer of 1887 for the Main Central Ry. at Waterville, Me., is shown by Drawings 14 and 15. They are set on each side of a single traverser bed, and occupy but little land. The arrangement will not prove elastic should extensions become necessary.

In new works, buildings are rarely set closer than fifty feet apart: forty will usually pass the fire insurance inspection, and thirty five has been proved to be far too close for efficient side light even with one-storied buildings.

The new shops of the Panhandle Ry. are set wide apart, with many large trees left standing in between them, this is a pleasure to the eye; but even in this country of cheap land, few railways subordinate considerations of economy, to the gratification of an æsthetic task, making the workshops ornaments in a natural park.

In vivid contrast to buildings spaced in this liberal manner, are the works of the L. & S. W. Ry. at Nine Elms, London (see Drawing No. 16), where the space under the viaduct carrying the four track main line, has to be utilized for shop room.

Freedom from snow, giving a wide liberty in roof design, simplifies the grouping of shops in Europe, and is illustrated for German practice by Drawing No. 6, showing a continued hip and farrow roof covering seventeen bays. With sufficient glass (part of it movable) there is no reasonable limit to the amount of light and fresh air admitted, and when artificial heat is necessary, the lack of height in the building, is a help to warming. In many instances the establishment is under one roof, as at St. Rollox on the Caledonian Ry., Scotland, the area being twelve acres—or the locomotive shops are under the one roof and the car shops under another. The number of trolley tracks and power cranes, and the compact setting, makes the handling of material and work a simple matter.

In plan, the tendency is, for the longitudinal axis of the main building, and the stall tracks, to run parallel with the main track, so that the plot of land required is long and narrow, as for instance in the Norwich new shops for the L. & Y. Ry., the erecting shop of 200 engines capacity, with six parallel tracks and a central machine bay, is 1,520 feet long—almost one third of a mile.

Although in Canada and the Northern States, shop roofs cannot be a continuous duplication of small pieces, yet the main buildings may have duplicate roofs, that is a uniform span may be adopted for erecting machine, boiler, car and paint shops, &c. The P. Ry. has so designed and built combined shops, that the portion originally used as car shops, can at slight expense be adopted for locomotive repairs, when the growth in business shall justify the increase of this section and the removal of the car department to another location.

On the general question of grouping, the late A. L. Holley may be quoted. He is talking more particularly of steel works, and says Joliet is perhaps the only establishment where railroads were laid out first and buildings made to fit, and in designing works, provision only an expedient for minimum amount of re-handling and hand labor, by going over all the operations on paper by different arrangements again and again, and not trusting to general ideas to be worked out when it is too late to move a building that happens to be in the way.

For intercommunication, not only between the chief offices and foremen's offices, but also between shop and shops and each bench and the tool room, electric bells, telephone service and displayed signals to call persons moving about through the works, to the nearest telephone, are daily receiving more general adoption, and their usefulness is so marked, that a single experiment with them is sure to result in their permanent use.

J. DAVIS BARNETT.

